Frontline Learning Research 5 (2014) 92 - 114
ISSN 2295-3159

Creative Solutions and their Evaluation: Comparing the Effects of Explanation and Argumentation Tasks on Student Reflections

Andria Andiliou[a], P. Karen Murphy[b]

[a] University of Bristol, United Kingdom

[b] The Pennsylvania State University, USA

Article received 12 February 2014 / revised 24 March 2014 / accepted 15 June 2014 / available online 27 June 2014

Abstract

Creative problem solving which results in novel and effective ideas or products is most advanced when learners can analyze, evaluate, and refine their ideas to improve creative solutions. The purpose of this investigation was to examine creative problem solving performance in undergraduate students and determine the tasks that support critical self-evaluations of creative solutions by comparing alternative types of reflective tasks. Participants (n = 103) first provided demographic information and responded to individual difference measures (i.e., divergent thinking, need for cognition, and beliefs about creative outcomes) and then read a problem scenario in which they assumed the role of a high school teacher who was asked to design a creative college preparatory course. Following, participants completed either an explanation reflective task or an argument based reflective task. Finally, participants evaluated their proposed course by rating it on characteristics that describe the originality and effectiveness of creative solutions. Findings confirmed the role of divergent thinking as a positive predictor of the originality of a creative solution, whereas, need for cognition, and academic major were positive predictors of the effectiveness of a creative solution. Participants rated their creative solutions differentially depending on their beliefs and the type of reflective task. Those whose beliefs aligned better with conceptualizations of creative outcomes assessed more positively the originality and effectiveness of their solution. The findings indicate that the argumentation task could potentially promote reflective and critical thinking about a creative solution as participants who completed the argumentation task evaluated their solution more conservatively.

Keywords: creative problem solving; creativity beliefs; self-evaluation; reflection; argument diagrams

Corresponding author: Andria Andiliou, Academic Staff Developer, University of Bristol, andria.andiliou@bristol.ac.uk
http://dx.doi.org/10.14786/flr.v2i3.87

1. Introduction

Creative problem solving is manifested in everyday life situations as well as in academic contexts (Diakidoy & Constantinou, 2001). It represents a goal directed cognitive process that results in the production of original and effective solutions when no obvious solution method is available (Antiliou, 2012). Consider the example of a mud engineer trying to find an innovative solution to prevent oil leaks from an underwater well, the example of a community center manager attempting to design activities that address the needs of a diverse community, or a group of preschool children trying to improvise the rules of a game to accommodate more players. In all cases, the situations call for novel but still effective solutions.

Many countries around the world have identified the development of creative thinking across subject areas as a core student learning outcome (Diakidoy & Constantinou, 2001) and have pushed for problem-based approaches that provide students with opportunities to construct creative solutions to authentic problems. However, students are often overwhelmed when they are asked to submit creative assignments or generate creative solutions. Arguably, one possible explanation for these negative reactions is that students have to rely on their creativity beliefs, but they are uncertain about the characteristics of creative outcomes. Consequently, they are unsure about how creative their proposed solution is or how to determine the creativeness of their solution. Unfortunately, the role of beliefs has not been adequately explored with respect to creative problem solving performance. As such, the first goal of the present study was to examine the contribution of cognitive and affective individual difference variables including an individual's beliefs on creative performance.

Besides creative performance per se, researchers have explored the self-evaluations of the proposed solutions and research evidence suggests that students' evaluations of self-generated solutions are superficial rather than reflective (Runco & Chand, 1994). In addition, students tend to engage in case-building about a solution. Instead of critically judging a solution, students argue and justify their solutions by discounting potential obstacles and consequences or curtailing the importance or extensiveness of the problem (Byrne, Shipman, & Mumford, 2010; Daily & Mumford, 2006; Nussbaum, 2008). In order to promote more critical reasoning and reflective evaluations in problem solving, researchers examined the effectiveness of structure supports such as prompts (Chen & Bradshaw, 2007; Ge & Land, 2003), directions (Feretti, MacArthur, & Dowdy, 2000; Nussbaum & Sinatra, 2003; Nussbaum & Kardash, 2005), cases (Choi & Lee, 2009; Hernandez-Serano & Jonassen, 2003), visual representations (Nussbaum, 2008; Nussbaum & Schraw, 2007), collaborative reasoning, and argumentation tools and tasks (Cho & Jonassen, 2002). These types of structure supports engage students in thinking about other perspectives, opinions, and approaches to the problem. This is particularly the case when the structure support involves argumentation as a mechanism to elaborate, make explicit the reasoning underlying the problem solving and to foster reflection about a solution (Andriessen, 2006; Oh & Jonassen, 2007).

A type of structure support, argumentation tools, were found to significantly improve students' argumentation skills and group problem solving with some marginal effects on individual problem solving (Cho & Jonassen, 2001; Oh & Jonassen, 2007; Uribe, Klein, & Sullivan, 2003). However, past research has not specified how argumentation tools and specifically, argument diagrams influence the self-evaluation of a solution when the problem calls for creative solutions which are original and effective. Thus, the second goal of this study was to address this gap in the literature by investigating the effects of an argument diagram on the self-evaluation of a creative solution that participants forwarded to a course design problem.

1.1 Creative Problem Solving

Several models have been proposed to describe creative problem solving including: The Simplex Model of Creative Process (Basadur et al., 1994), the Creative Problem Solving framework (Isaksen et al., 1994), and the Model of Creative Thought (Mumford et al., 1991). In the Simplex Model the problem solver moves in cycles of ideation and evaluation that occur in different phases of problem solving during which the learner generates and formulates the problem, solves the problem and implements the relevant, appropriate, and original ideas (Runco & Chand, 1994). According to the Creative Problem Solving

framework, the learner needs to understand the problem, generate solution ideas, and plan for action by developing solutions that could be effectively implemented (Treffinger, 1995). In Mumford et al. (1991) model of creative thought the learner combines and reorganizes categories or concepts to develop a new understanding of the problem (ideas), which are then evaluated and implemented. These aforementioned models illustrate that creative problem solving evolves across several cognitive subprocesses initiated by the construction of a problem space, the generation of ideas, and the evaluation of a selected solution.

Creative problem solving is a form of ill-structured problem solving, which results in the production of original and effective solutions (Antiliou, 2012). Drawing on a review of the empirical literatures of creative and ill-structured problem solving, certain individual difference variables were expected to have an effect on the creativity of a solution with respect to its originality and effectiveness. Specifically, divergent thinking that is the ability to generate multiple ideas was found to be predictive of creative problem solving performance (e.g., Hunter et al., 2008; Reiter-Palmon et al., 2009; 1997). In addition, research evidence indicated that need for cognition that represents an individual’s tendency to engage in and enjoy effortful cognitive endeavours (Cacioppo, Petty, & Kao, 1984) also, predicts creative problem solving performance (Butler et al., 2003; Hunter et al., 2008; Osburn & Mumford, 2006).

Students’ domain knowledge and their beliefs about the characteristics of creative outcomes can potentially exhibit an influence on creative problem solving performance. Research evidence suggests that problem solvers’ perceptions of a task and their domain knowledge impacts the search for relevant information, the representation of the problem, and the evaluation of potential solutions (Jonassen, 1997; Voss et al., 1991). Also, evidence indicates that knowledge of the important concepts and principles of a domain contributes in better performance on ill-structured tasks (Shin, Jonassen, & McGee, 2003; Voss & Post, 1988) and serves as the foundation of creative solutions (Weisberg, 2006).

Evaluation is a component of problem solving and it represents the metacognitive process during which problem solvers reflect and assess a proposed solution. Evaluation is essential for ill-structured problems that require a creative solution because it is the process by which problem solvers can determine whether a proposed solution meets the creative criteria of originality and effectiveness. According to Voss and her colleagues (1981) argumentation is a means for problem solvers to evaluate more analytically a solution by elaborating and clarifying the solution and identifying its limitations. Researchers have experimented with graphic organizers such as argument diagrams in order to promote critical and reflective thinking in writing tasks. For example, Nussbaum and Schraw (2007) found that argument diagrams supported better integration of arguments and counterarguments in writing tasks. For the present study, our second aim was to determine whether an argument task (i.e., argument diagram) promotes more reflective critical self-evaluations of a potentially creative solution in comparison to an explanation task.

1.2 Explanation and Argumentation for Critical Thinking

Explanation and argument tasks have been used to promote and assess understanding, critical thinking, conceptual change, and problem solving (Reznitskaya, Anderson, & Kuo, 2007; Jonassen & Kim, 2010; Nussbaum & Sinatra, 2003; Willey & Voss, 1999). Explanation is a constructive learning activity during which learners elaborate and clarify an idea by explaining it to oneself and it was found to lead to enhanced learning, more accurate self-assessments, and more effective problem-solving (Fonseca & Chi, 2011). When learners elaborate they generate inferences and integrate information with prior knowledge. The self-explanation effect was found to be positive both for learners with low and high prior knowledge. A possible interpretation of this result is that for individuals with low knowledge, self-explaining allows them to generate inferences to fill their knowledge gaps and for learners with high prior knowledge, self-explaining allows them to repair their existing mental models (Chi, 2000; Fonseca & Chi, 2011). Research findings indicate that self-explanation can be a powerful learning strategy due to the underlying cognitive mechanisms that allow learners to identify and remedy knowledge gaps by generating inferences and to develop and repair their knowledge representation models. Thus, when learners move beyond simply knowledge-telling with summaries or paraphrased statements and are engaged in self-explanation through inference generation and knowledge integration they seem to gain a deeper understanding. However, even if

self-explanation to one-self represents a constructive learning activity it was found to be somewhat less effective in learning and problem solving tasks when compared to more interactive learning activities such as responding to question prompts, explaining to someone else, and discussing with a partner to generate collaborative explanations. In the present study, within the context of a problem solving task an explanation prompt was compared with an argument task to examine the degree to which the tasks promote reflective thinking when evaluating a proposed creative solution.

Argumentation was conceptualized by Kuhn (1991) as the cognitive process of formulating and weighting the arguments for and against a course of action, a point of view, or a solution to a problem. Argumentation skills are comprised of the skill to generate reasons, offer evidence, and provide counterarguments and rebuttals. Three theoretical frameworks have been applied to analyze argumentation based on rhetorical and dialectical arguments in educational settings. Rhetorical arguments are put forward to persuade or convince others about a claim or proposition without consideration to alternative positions (Toulmin, 1958). Dialectical arguments are based on the dialogue between supporters of alternative positions during a dialogue game or a discussion (Jonassen & Kim, 2010). Through dialectical argumentation within an individual or within a group, individuals resolve differences, compromise between multiple opinions, and convince on the advantages of a position.

Researchers in the learning sciences draw primarily on three theoretical approaches to analyze and evaluate the quality of argumentation: Toulmin's rhetorical argumentation framework, pragma-dialectics (van Eeemeren & Grootendorst, 1992) and Walton's (2000) dialogue theory. Toulmin has proposed an argument scheme to describe the structure of effective argumentation that includes a sequential set of components: a claim that expresses the position, facts or opinions that serve as data in support of the claim, a warrant as justification, and elaborative elements such as a backing, qualifier, and rebuttal to potential counterclaims. Although Toulmin's framework is useful for analyzing rhetorical argumentation to determine the soundness and effectiveness of a line of reasoning of an individual (Andriessen, 2006), it has two primary limitations: its complexity (e.g., warrants are often implicit) and its focus on the perspective of one proponent (Leitão, 2003; van Eemeren & Grootendorst, 1999) instead of argumentation as "a discourse phenomenon" (Andriessen, 2006) especially with reference to educational contexts.

Two theoretical models that are more applicable to the dialectical nature of argumentation as it is manifested in educational contexts are the pragma-dialectics (van Eeemeren & Grootendorst, 1992) and dialogue theory (Walton, 2000). Based on the pragma-dialectics, argumentation is a means of resolving differences of opinions through critical discussions that evolve in four stages. First, people present their positions at the confrontation stage, they assume their roles and agree on procedures at the opening stage, they defend and challenge during the argumentation stage and at the concluding stage they decide who has prevailed the critical discussion. Another collaborative view of argumentative discourse is conceptualized in Walton's dialogue theory (Walton, 2000) in which Walton argues that argumentation is a goal-directed and interactive dialogical activity during which individuals reason together about arguments to generate one proposed solution. Walton (2000) identified specific forms of dialogue (e.g., information seeking, negotiation, persuasion, inquiry) along with argumentation schemes comprised of critical questions and moves to model and support argumentation. Educators can draw on the schemes suggested in dialogue theory to plan, organize, and evaluate classroom and online discussions, and use argumentation as a vehicle for critical thinking and problem solving. In the present study an overarching critical question was used to stimulate student argumentation with an imaginary group of stakeholders with the purpose of exploring the potential of a creative solution to an authentic problem.

1.2.1 Supporting Argumentation

Researchers have documented that acquiring the skills to argue effectively is challenging both for adolescents and young adults (Felton & Kuhn, 2001; Reznitskaya et al. 2001). In order to engage students in argumentation and promote the development of argumentation skills educational researchers have designed and experimented with argumentation supports in the contexts of reading, writing, and problem solving tasks. Among these argumentation supports are directions, computerized and face-to-face collaborative argumentation, and visual argumentation aids.

Goal directions have been used as a means to promote reflective argumentation in problem solving and writing tasks. For example, Nussbaum and Sinatra (2003) asked undergraduate students who provided a wrong answer to a physics problem in which they had to predict the path of a falling object to counter-argue by providing reasons why a person would hold an opposing position. The researchers found that students who proposed counterarguments had a more integrated understanding of the problem situation and the important underlying concepts. The effectiveness of directions in supporting argumentation varied based on the goal they conveyed. When students were instructed to persuade an audience instead of explaining their position or solution, evidence indicated that they engaged in case-building, the overall quality of writing was poorer with fewer counterarguments but more reasons in justification of their position. Alternatively more specific directions that guided students to generate complete arguments were more effective in facilitating student argumentation. When Nussbaum and Kardash (2005) gave goal directions that varied in generality (i.e., opinion, reason, counterargue/rebut), they found that the group that received more specific directions to persuade by generating reasons, evidence, counterclaims and rebuttals, produced writing of better overall quality, more balanced, and the participants offered more counterarguments and rebuttals. In a follow-up experiment, Nussbaum and Kardash (2005) compared the effects of two types of goal directions (e.g., express an opinion or persuade an audience) and the effects of a two-sided non-refutational text. Undergraduate students who were directed to express an opinion and read the text produced essays of better overall quality, wrote more elaborative arguments and offered more counterarguments in comparison to those who were directed to persuade as the text stimulated students' thinking. Directions to persuade had a significant negative effect on the overall quality of argumentation only for students who did not read the text. Researchers raised caution about persuasion directions as it is possible that students' rely on a misconception that they are more effective in convincing an audience by elaborating on their position than raising counterarguments (Ferretti, MacArthur, & Dowdy, 2000; Nussbaum & Kardash, 2005). In order to promote more balanced and reflective reasoning researchers have utilized other structure supports such as collaborative reasoning discussions and visual argumentation aids including computer-scaffolding tools, outlines and diagrams.

Researchers have investigated the effect of collaborative argumentation both computerized and face-to-face to facilitate students' critical reasoning and argumentation within the context of problem solving tasks. In two exemplar studies researchers examined the effects of argumentation scaffolds and question prompts on the quality of argumentation, the group problem solving performance and transfer to individual problem solving (Cho & Jonassen, 2003; Oh & Jonassen, 2007). Typical argumentation scaffolds included sentence openers that helped to explicate a solution, agree or disagree with a solution, put forward evidence, and elaborate on the solution. In addition, guidance questions functioned as scaffolds (e.g., How can you verify the accuracy or value of your solution?) in the collaborative discussion environments. Researchers found that the argumentation scaffolds improved the quality of the discussion in terms of the number of argument components including claims on how to solve the problem and evidence to support the solution (Cho & Jonassen, 2003; Oh & Jonassen, 2007). There was also improvement in the overall quality of problem solving subprocesses including problem definition, selection of relevant information, hypothesis generation and testing, solution development and evaluation. However, in both studies the researchers did not detect significant transfer effects of argumentation scaffolding on individual problem solving. Thus, suggesting that learners may need long-term and more comprehensive opportunities for extended engagement in collaborative problem solving to effectively transfer and apply argumentation skills in individual problem solving.

Collaborative discourse was also effective in facilitating argumentation when combined with instruction on basic argumentation concepts and reading of multiple texts. In a study of middle school students, Martunen and Laurinen (2006) found that after reading three texts and participating in pair conversations on the topic of genetically modified organisms, the student-constructed argumentation diagrams were more elaborative and reflective as they included more themes and arguments. Moreover, Kim (2001) found that incorporating a metacognitive group monitoring activity in collaborative reasoning discussions had contributed in more dialogic and reflective student writing. In addition, the counterarguments and rebuttals increased in the post-discussion essays and the essays provided evidence that students were attentive to their reasoning by reflecting and evaluating their position. In conclusion, guided

opportunities in which learners participate in argument-based discourse facilitate development and internalization of argumentation knowledge and skills, and improve both the quality of the arguments and the peer dialogues.

Visual argumentation aids such as argument diagrams have been utilized by researchers to promote coherent and organized argumentation with well-integrated arguments and counterarguments in support of a final position. In a series of studies Nussbaum and Schraw (2007) examined the effectiveness of a graphic organizer to guide more balanced and reflective argumentation. They found that both instruction about the criteria of a good argument and the graphic organizer improved the quality of writing, increased the number of counterarguments, and the overall integration score. However, the students who used the graphic organizer preferred to apply refutation as an integration strategy in comparison with students who received criteria instruction and primarily used weighing and synthesizing opposing perspectives into a creative position. In a follow-up study, that aimed to facilitate students to become more metacognitively reflective and explore perspectives on an issue before integrating them into a final position, Nussbaum (2008) modified the graphic organizer to an Argumentation Vee Diagram (AVD). In this study Nussbaum examined whether an elaborative intervention that utilizes the diagram with instruction on how to integrate arguments and counterarguments, and discussion of the criteria of evaluating the strength of arguments and counterarguments results in better argumentation and has a transfer effect. The experimental group improved their writing in terms of integration over three sessions using most frequently the synthesis strategy but there was no significant transfer effect to a task in which the diagram was removed. In another study, when fifth graders collaboratively used an argument diagram, they generated more coherent arguments than when they collaborated to list pro-con positions (Scwarz, Neuman, & Biezuner, 2000). Thus, the studies provide evidence that the argument diagrams have the potential to stimulate consideration of counterarguments and facilitate more elaborated and coherent argumentation but more research is needed to determine whether the use of diagrams enhances reflective and critical thinking about complex issues.

Virtual graphic tools have also been used to support student argumentation and engagement in critical discussions. Typically computerized argumentation diagrams have the capacity to represent both the components of an argument and relations of support and disagreement (Jonassen & Kim, 2010). In their study of the VCRI argumentation tool, Munneke, van Amelsvoort, and Andriessen (2003) examined the role of argumentative diagrams that were constructed in advance individually or collaboratively during an electronic discussion in supporting student interaction with the purpose of writing a collaborative text on genetically modified organisms. The researchers found that diagrams that were constructed in advance helped students to focus their subsequent discussions on argumentation and were used as information sources and collaborative diagrams were also used for note-taking to summarize the discussion. Thus, the diagram helped to maintain focus and functioned as an aid for organizing and maintaining coherence during the discussion. Munneken and colleagues (2003) noted though, that even if diagrams stimulated collaborative discussions still argumentation was one-sided as most diagrams were very unbalanced. Another study conducted by Easterday, Aleven, and Scheines (2007) provided further evidence of the effectiveness of argument diagrams as a graphic organizer for argumentation. Learners in this experimental study who analyzed public policy problems using a causal diagram organized better their perceptions of the arguments in comparison with students who only read about the problem in a text. However, students who used the diagramming tool learned more about constructing causal arguments as they were engaged in a more constructive activity while using the tool to formulate their arguments. As Newell and colleagues (2011) argued in their review of the studies on teaching and learning argumentation, the diagrams printed or virtual help learners manage the complexities of argumentation and especially the task of considering alternative perspectives and integrating arguments with counterarguments but more evidence is needed to support whether they facilitate more critical and reflective thinking.

1.3 Purpose of the Study

The purpose of the study was to examine creative problem solving performance in undergraduate students and compare how alternative tasks (e.g., explanation or argumentation) support reflective self-evaluations of creative solutions. Two research questions guided our investigation:

How do individual differences in divergent thinking, need for cognition, beliefs about creative outcomes, and academic major impact the creativity of a solution with respect to its (a) originality and (b) effectiveness?

To what extent does a reflective task (i.e., an explanation task or an argumentation task) differentially support the students' self-evaluation of their creative solution?

Based on the review of literature the following five hypotheses were forwarded:

Hypothesis 1.1. Students who are strong divergent thinkers and high in need for cognition will propose creative solutions that are both original and effective.

Hypothesis 1.2. Students who conceptualize creative solutions as both original and effective will develop a solution that is highly effective and may or may not be as original. These students will also evaluate their creative solutions more positively.

Hypothesis 1.3. Students who possess more extensive prior knowledge, based on their academic major, will develop highly effective solutions.

Hypothesis 2.1. For students who complete the argumentation task, the effectiveness of the proposed creative solution will strongly and positively predict the self-evaluation of the solution with respect to its effectiveness.

Hypothesis 2.2. For students who respond to the explanation task, the effectiveness of their proposed creative solution will be less predictive of their self-evaluation of the effectiveness of the solution.

2. Method

The purpose of this study was to explore creative problem solving performance in undergraduate students and compare alternative tasks that support reflective self-evaluations of their proposed creative solutions. The study was designed based on a single-factor, between groups design with two comparison groups (i.e., Explanation or Argumentation Task).

2.1 Participants

For this study participants were recruited from an undergraduate educational psychology course at a public research university in the United States. The completion rate was 82% with 103 volunteers completing the study. The sample was comprised of primarily sophomores (52%) and freshmen (30%), the majority were females (n=88), and more than half of the participants were education majors (57%) in comparison to 43% of non-education students (e.g., communication sciences and disorders, kinesiology). The demographics were comparable to most introductory courses required for teacher certification.

2.2 Measures

2.2.1 Demographics

Respondents completed a demographic cover page in which they provided background information including their academic major, academic classification, courses they completed in preparation for the transition to college, and courses they enrolled or completed pertaining to curriculum and instruction. Participants also listed and described their teaching experiences.

2.2.2 Divergent Thinking

The two divergent thinking tasks were derived from the tasks in Guilford's Consequences' Test A' (Christensen, Merrifield, & Guilford, 1953). For each task students had two minutes to generate as many possible results to each of these hypothetical scenarios: (a) What would happen if a new invention makes it unnecessary for people to eat? (b) What would happen if a new invention makes it unnecessary for people to

sleep? The responses were scored for ideational fluency operationalized as the number of distinct valid ideas recorded by a respondent excluding any duplicates or irrelevant ideas due to a misinterpretation of the scenario. On average, for the two divergent thinking tasks participants generated M_1=6.11(2.46) ideas and M_2=5.52(2.27). Due to their marginal internal consistencies (α=.63), the two scores were entered as separate divergent thinking indicators for data analysis.

2.2.3 Beliefs Questionnaire

A 28-item Likert scale designed for the purposes of this study was administered to gauge participants' beliefs about creative outcomes with reference to a creative course. Twelve items targeted characteristics of a creative course related to its (a) originality (i.e., innovative, unusual, original, novel, unique, and imaginative) and (b) effectiveness (i.e., successful, affordable, effective, implementable, goal-directed, and feasible). These characteristics are recurring terms that describe creative outcomes in the extant literature of creativity and creative problem solving. The remaining 16 items were distracters. An example of an item on the belief scale is: "Creative high school courses are implementable." Participants rated the belief scale items with a score ranging from Not Very (0) to Very (5) to indicate how typical the characteristic is of a creative course.

A factor analysis with a Principal axis factoring (PAF) and a Promax rotation was conducted with the 12 characteristics of creative courses to determine the underlying structure of the belief scale. The Promax rotation was selected because it is a type of rotation that aids the interpretation of the factor analysis results when the factors are believed to be correlated as in this case (r_{12}=.52).

Three factors were extracted with eigenvalues of 37.066, 10.688, and 6.996 respectively and they exceeded the criterion of 1.0 based on the Kaiser-Guttman rule (Guttman, 1954; Kaiser, 1960). However, only two underlying factors were detected in the scree plot. The characteristic affordable was the only one that loaded on the 3rd factor, which explained 6.996 % of the data. This characteristic was the only item that targeted financial aspects of a creative course and this is possibly why this characteristic failed to load on the two first factors that represented the effectiveness and originality of a course. Thus, this item was removed and a second factor analysis was conducted with the 11 items. Two factors emerged from the final factor analysis with eigenvalues of 4.828 and 1.497, which explained 39.984% and 9.917% of the variation in the data, respectively. As evidenced in Table 1, nine items had loadings greater than the Harman criterion value of .40.

The two detected factors represent underlying characteristics of creative courses with the first factor representing the effectiveness dimension and the second factor representing the originality dimension of a creative course (r_{12} =.57). Characteristics that underlie the effectiveness of a creative course included successful, effective, innovative, implementable, and feasible. Characteristics that underlie the originality dimension of a creative course included the characteristics imaginative, unique, novel, and original. A belief scale with the nine items was formulated with acceptable internal consistency (α=.87). The internal consistency of the two component subscales were α_1= .84 for effectiveness and α_2=.81 for originality. The composite score for the entire belief scale ranged from 0 to 45 with higher scores indicating beliefs in agreement with current conceptualizations of creative outcomes in the literature. The average belief score was M=26.89(7.29) suggesting that participants' beliefs were in moderate alignment with these conceptualizations.

Table 1

Coefficients for the Factor Analysis with Promax Rotation for the Beliefs Scale

Characteristic	Effectiveness	Originality
Successful	**.998**	-.153
Effective	**.959**	-.195
Innovative	**.605**	.070
Implementable	**.509**	.181
Feasible	**.440**	.169

Imaginative	.004	**.812**
Unique	.081	**.757**
Novel	.095	**.619**
Original	.233	**.619**
Unusual	-.231	.367
Goal-directed	.325	.307
Eigenvalues	4.828	1.497
Percentage of Variance	39.984	9.917

Note. Factor loadings >.40 are in boldface.

2.2.4. Need for Cognition Scale

The 18-item abbreviated Need for Cognition Scale (Cacioppo, Petty, & Kao, 1984, p.306) was administered (α=.79) to assess participants' tendency to engage in and enjoy effortful cognitive endeavours. An example item from the scale is the following: "I would prefer complex to simple problems". Participants rated the statements with a score ranging from Not Very Much (0) to Very Much (5). For the scoring of the scale, a composite Need for Cognition score was calculated and it ranged from 0 to 90. On average, participants manifested moderate to low Need for Cognition M=48.5(10.46).

2.2.5 Solution Self-Evaluation Questionnaire

Finally, participants evaluated their creative course on a 16-item Likert scale questionnaire developed for the study, which consisted of two distracter items and 14 items that represented criteria of a creative solution with respect to its originality (i.e., innovative, unusual, original, imaginative, novel, unique, and risky) and effectiveness (i.e., effective, successful, affordable, implementable, goal-directed, feasible, and organized). These items reflected descriptive characteristics of creative outcomes identified in the extant theoretical and empirical literature of creativity and creative problem solving. Participants rated how creative their proposed solution was based on the aforementioned characteristics on a scale ranging from Not Very (0) to Very (5).

A factor analysis with a Principal axis factoring (PAF) and a Promax rotation was conducted with the 14 items after the distracters were removed. Two factors emerged with eigenvalues equal to 6.086 and 2.452, which explained 40.58% and 14.01% of the data, respectively. The factor intercorrelation was moderate (r_{12}=.49). Table 2 summarizes the loadings on the two factors based on the pattern matrix.

Based on the results of a factor analysis two subscales were formulated: the originality self-evaluation and the effectiveness self-evaluation subscale with seven items each. Both subscales ranged from 0 to 35 and had acceptable internal consistency indices of α_1=.87 and α_2=.88 respectively. On average, participants evaluated their proposed course solution low in originality M=18.96(6.73) and moderate in effectiveness M=26.69(5.38).

Table 2

Coefficients for the Exploratory Factor Analysis with Promax Rotation for the Self-Evaluation Scale

Characteristic	Course Effectiveness	Course Originality
Effective	**.81**	.04
Successful	**.78**	.10
Affordable	**.74**	-.30
Organized	**.73**	.10
Goal-directed	**.69**	.00
Implementable	**.69**	-.09
Feasible	**.65**	.04
Unique	.08	**.86**
Imaginative	-.02	**.80**

Unusual	-.13	**.75**
Original	.13	**.68**
Novel	.06	**.68**
Risky	-.40	**.60**
Innovative	.34	**.56**
Eigenvalues	6.09	2.45
Percentage of Variance	40.58	14.01

Note. Factor loadings >.40 are in boldface.

2.3 Procedure

Participants completed the study through an online survey system (Qualtrics) that randomly assigned them to a condition either the Explanation (n_1=53) or the Argumentation (n_2=50) task. The study was self-paced as students completed it in one sitting at their own pace. Students first provided demographic information and responded to two counterbalanced divergent thinking tasks. Following, they completed a beliefs questionnaire and the Need for Cognition Scale. Then all participants read the same problem scenario and in response to it they developed a creative course as a solution to the problem described in the scenario. Following participants responded to a reflective task (i.e., an explanation or an argumentation task) about their proposed creative course. Finally, all participants evaluated the creativity of their course by rating it on a scale with a set of characteristics that describe the originality and effectiveness of a creative solution.

2.4 Problem Solving Task

The problem scenario was originally developed by Hunter and his colleagues (2008) for a study of undergraduate students' idea generation and problem solving. The specific scenario was selected for two reasons: (a) it had been previously used with undergraduate students and has yielded acceptable interrater agreement scores (0.70-0.80) with respect to the originality and quality scores assigned to the solution and (b) the embedded problem solving task is ill-structured as it requires students to: extract the important and relevant information from the scenario, identify the parameters and constraints for solving the problem, apply personal beliefs about creative courses and creative teaching, draw on their knowledge and experiences to define the problem, make judgments, and establish criteria for evaluation.

The scenario required participants to assume the role of a high school teacher asked to design a creative college preparatory course for the high school's seniors to better prepare them for college and reduce the college dropout rate among this high school's graduates. The final paragraph in the problem scenario explained the task: "*In her description of the requirements for the course, the principal makes one point very clear, the senior prep course needs to be a creative high school course designed to prepare the high school students for college. She emphasized that you need to take a creative approach in designing and teaching the course. The principal has asked you to 1) identify the overall goal of the course and 2) list and describe the specific learning activities that you will include in the course*." Also, for the purposes of the study we modified the problem scenario in two ways. First, any descriptions or conceptualizations of a creative course were removed so that participants rely on their own beliefs and understandings of a creative course. Still we emphasized in the scenario that the problem solver needs to take a creative approach in designing and teaching the course. Second, in the final paragraph we identified the two specific tasks that participants had to complete after reading the scenario.

We conducted two pilot studies followed by two focus group discussions in order to gather evidence for the comprehensibility and the face validity of the problem scenario and the problem solving task. The pilot study participants were representative of the sample (i.e., non-education and education majors) and in general the students found the directions clear and the scenario understandable. They also acknowledged the authenticity of the problem scenario as they pointed that it challenged them to provide a solution to a real life

problem: the fact that high school students are not prepared for the academic, social, and emotional challenges of the transition to college. Pilot study participants said that once they read the problem scenario they had to pause and reflect on what their needs were when they moved to college and what is important for a student to succeed in college. Overall, the authenticity of the problem scenario and its relevance to students' recent college transition experiences seems to have motivated participants to engage with the task as they agreed on the importance of designing a high school course to prepare students for college.

2.4.1. Coding

A coding scheme was developed to summarize the responses that participants provided to the problem solving task. Specifically, the scheme was used to code the learning activities participants suggested for their creative high school course. An iterative procedure was followed to develop the coding scheme and establish its validity. The researcher and an independent coder (Coder A) applied a keyword content analysis approach to identify the task-relevant units within a response. A task-relevant unit was defined as any distinct task-relevant statement that captured learning activities that participants generated for their high school course. A learning activity was defined as any learning experience, enactive (i.e., actual doing) or vicarious (i.e., students observe, listen or are engaged in other ways), designed for the learners to attain an instructional goal such as the acquisition of information, knowledge, skills, abilities, attitudes and strategies (Antiliou, 2012, p. 66).

The first author began by reading all of the responses to generate an initial set of coding categories to summarize the responses to the question prompt that participants recorded. This initial review of responses revealed that participants recorded learning activities as well as assessment activities and other instruction and course design elements such as materials, educational technology, and learning goals. Following, the researcher provided directions to another colleague (Coder A) to develop independently her version of the coding scheme. The directions included the problem scenario, the problem solving task, a set of coding guidelines and an example of a coded response. Then, Coder A proceeded to read the entire set of responses to independently generate a second version of the coding scheme.

In the two discussions that followed between the first author and Coder A, the two independent coders analyzed, compared, and synthesized the two alternative coding schemes to generate a merged coding guide that included a coding scheme and a set of guidelines with definitions, assumptions, and decision rules. There was consensus that the coding scheme should capture task-relevant units that identified not only learning and assessment activities but also other instruction/course design elements (e.g., instructional materials or educational technology, etc.).

A total of 47 coding categories were included in the coding scheme and they are summarized under ten overarching categories including discussion-based activities, problem solving activities, experiential learning activities, reading and writing assignments (see Table 3 for the complete list of categories). The 47 coding categories represented learning or assessment activities, as well as other instruction/course design elements. Six of the 47 coding categories were further divided into four additional specific subcodings. For example, the category modelling had two subcodes: instructor model and other models. Also, the category expository writing had two subcodes: extended and brief. In the case of coding categories with more specific subcodes, the coding was done by applying the more specific subcode. The coding guide was used for a trial coding (10%) followed by a discussion to resolve potential differences, refine the scheme, and clarify the decisions rules.

Following the development and validation of the coding scheme, the intercoder agreement for the reliability of the coded responses was examined. The researcher and Coder A independently coded another 20% of the responses for this purpose. In each response, the coders (a) identified the total number of task-relevant units and (b) coded the task-relevant units including the learning activities or other instruction/course design elements.

A total of N=349 valid task-relevant units were recorded by the participants. The intercoder agreement for the total number of task-relevant units was α=.79 and for the type of code assigned to a task-relevant unit was α=.72. Both indices were above the moderate criterion .70 selected for the conservative

Kalpha Coefficient of intercoder agreement. In a discussion that followed, the coders first resolved disagreements on the number of task-relevant units and then disagreements on the assigned codes in order to reach consensus.

2.4.2. Scoring

The creativity of a course that participants proposed was operationalized with respect to the average originality and effectiveness of the valid task-relevant units. Each valid task-relevant unit that a participant recorded was scored for its originality and effectiveness. Among the valid task-relevant units, 315 units were classified as learning or assessment activities. Another 34 task-relevant units represented instruction/course design elements, which referred to aspects of instruction or course design including materials, educational technology, the structure of the course, and the learning environment.

Originality: Originality was defined as the rareness of occurrence of a task-relevant unit within the pool of valid units (N=349) generated by all participants. The originality score (x) assigned to a valid task-relevant unit (i) was the rareness proportion of the specific code within the pool of (a) learning/assessment activity units or (b) instruction/course elements, depending on the nature of the coded unit. For example, a task-relevant unit with the code instructor modelling appeared 55 times so its proportion of occurrence within the pool of learning/assessment activities was 55/315=0.18 and its rareness of occurrence was 1-0.18=.82. Similarly, a task-relevant unit with the code educational technologies appeared 6 times within the pool of the 34 instruction/course design elements, thus its proportion of occurrence was 6/34=0.18 and its rareness of occurrence was 1-0.18=.82.

The average originality score for the solution proposed by a participant (j) was: average originality = $\frac{\sum_{i=1}^{m_j} x_i}{m_j}$. The average originality score (x) is the sum total of the rareness proportion (x) for every ith valid task-relevant unit divided by the number of valid task-relevant units (m) recorded by each participant.

Effectiveness: The potential effectiveness of a learning activity was defined as the degree to which a learning or assessment activity or other instruction/course design element could contribute to the smooth transition and academic success during the first years of college. An effectiveness rubric was developed to operationalize and score each task-relevant unit (see Appendix). The rubric was developed by drawing on the literatures of instructional design, and college transition and persistence and instructional design (Eggen & Kauchak, 2010; Goldbrick-Lab et al., 2007; Louie, 2007; Pritchard et al, 2007; Roe Clark, 2005). The effectiveness scores ranged from Inadequate (0) to Strong (4) effectiveness. The effectiveness of a learning activity or other task-relevant unit was considered Strong if (a) it targeted important information, knowledge, abilities, skills, or strategies for smooth transition and academic success in the first years of college and (b) it strongly aligned (i.e., directly relevant) with the identified overall goal of the course. Examples of potentially effective activities include those that targeted writing, note taking, and test taking skills but also coping strategies and interpersonal skills.

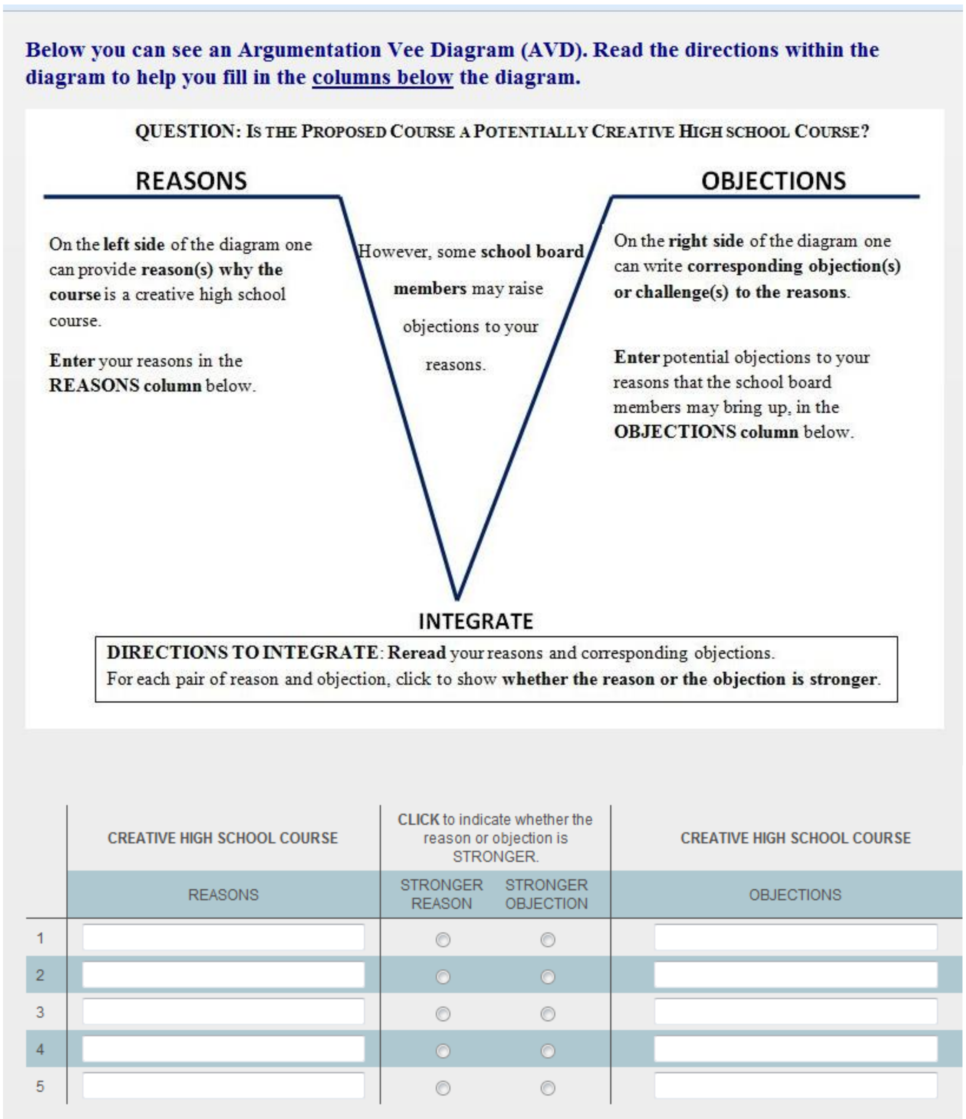
In order to establish the reliability of the effectiveness scores another colleague was trained to serve as a second rater using a subset of the pilot data. Following, the researcher and the second rater independently, scored two subsets of the data to reach an acceptable interrater agreement level (α=.82). When all valid task-relevant units were scored for their potential effectiveness, an average effectiveness score for a solution was estimated by applying the following formula: average effectiveness = $\frac{\sum_{i=1}^{m_j} y_i}{m_j}$. For each participant (j), the average effectiveness score (y) is the sum total of the effectiveness score (y) for every ith valid task-relevant unit that each participant generated divided by the number of valid units (m) proposed by each participant (j).

2.5.1 Reflective Task

In both experimental conditions participants completed one of two alternative post problem solving tasks. Students in the Explanation condition (n_1=53) were directed to “Provide an explanation of their high

school course to the school board members". The explanation task required a short written response to this prompt.

Students in the Argumentation condition (n_2=50) completed an argument diagram. The argumentation diagram is a modified Argumentation Vee Diagram[1] (Nussbaum, 2008) adapted (a) for the online administration of the study and (b) for constraining participants to use weighing as the integration strategy between the arguments and counterarguments. Figure 1 presents the argumentation diagram administered in this study. The overarching question inquired whether the proposed course is a potentially creative course. The participants generated reasons in favour of their creative course and corresponding potential objections of the school board. Then they were directed to reread the reasons and objections and decide for each pair whether the reason or objection was stronger. Participants could offer up to 5 pairs of reasons and objections.



---

[1] Two pilot studies (n_1=19; n_2=9) and focus group discussions were conducted to ensure that the modified argumentation diagram is comprehensible and that participants are able to complete the diagram. Please, contact the first author for information on the pilot studies.

Figure 1. The argumentation diagram utilized in the study.

3. Results

The purpose of the study was to examine problem solving performance and identify reflective tasks that better support students' self-evaluations of their proposed creative solutions. Participants completed online a set of individual difference measures before responding to the problem solving task in which they assumed the role of a high school teacher who was asked to design a creative college preparatory course for the high school senior students. The participants identified the overall goal of their high school course and generated specific learning activities for the course. Following they completed an explanation or argument reflective task and rated the creative course in terms of its originality and effectiveness. A summary of the creative solutions that participants forwarded is followed by the presentation of the descriptive statistics and corresponding statistical models performed to answer the two research questions.

3.1 The Creative Solutions

Participants designed a creative course to reduce the high college dropout rate among the high school graduates and better prepare them for the transition to college. Participants listed and described specific learning activities that they would implement in their course. Among the most widely referenced learning activities within the pool of valid task-relevant units generated by the respondents were instructor led activities in which the instructor or another more experienced individual (e.g., guest speaker) was responsible for providing instructional support such as presenting content and sharing experiences. Equally popular were activities that were based on experiential learning, such as simulations, fieldtrips, and student presentations.

Table 3

Frequency of Occurrence of Overarching Categories within Valid Task-Relevant Units (N=349)

Overarching Category	Frequency of Occurrence f	Percentage of Occurrence %
Discussion	18	5.16
Warm Up	4	1.15
Instructor Led	94	26.93
Problem Solving	6	1.72
Experiential Learning	93	26.65
Research	13	3.72
Writing Assignments	58	16.62
Reading Assignments	3	0.86
Classroom Assessment	26	7.45
Instruction/Course Design	34	9.74

Other learning activities included writing (i.e., expository, persuasive, reflective, organizational aids) and reading assignments (e.g., textbooks, articles, or reports), discussions including student-centered discussions, debates, and discussions with experts. Moreover, participants identified research activities, for example searching information about an academic topic, and searching about potential careers and colleges, and learning activities based on problem solving (e.g., decision making).

Classroom assessments such as formative, summative, and diagnostic assessments were included in participants' proposed learning activities (n_1=26; 7.45%). Several students (n_2=34; 9.74%) suggested other instructional or course design elements such as materials and educational technologies. It is possible that these students had interpreted the prompt more broadly than intended such that they provided ideas about how they would organize the course and plan instruction to attain the goals of the creative course.

3.2 Predictors of Creative Solutions

In the first research question we examined the extent to which individual difference variables including divergent thinking, need for cognition, beliefs about creative outcomes, and academic major impact the creativity of a proposed solution in terms of its average originality and potential effectiveness. Across the sample, the mean average originality score was high M=0.9(0.09) and the mean average effectiveness score was moderate M=3.23(0.59).

Descriptive statistics for the three continuous predictors are presented in Table 4. With respect to their academic major, 57% of the sample were education majors and 43% non-education majors (e.g., communications, kinesiology, or human development). Participants exhibited moderate divergent thinking ability and on average they generated six valid ideas. Considerable more variability was evident in participants' need for cognition which was moderate to low.

Table 4

Means and Standard Deviations of Predictors of Creative Solutions

Variables	*M*	*SD*	*Range*
Divergent Thinking (I)	6.11	2.42	-
Divergent Thinking (II)	5.54	2.23	-
Need for Cognition	48.50	10.50	0-90
Beliefs	26.92	7.31	0-45

Moreover, the students' beliefs about creative outcomes mean score was M=26.89(7.29), which indicates that participants' beliefs were somewhat in alignment with conceptualizations in the literature. Participants rated high characteristics of creative outcomes pertaining to their effectiveness [i.e., feasible M=3.98(1.24), effective M=3.42(1.04), and successful M=3.23(1.12)]. They also acknowledged as important characteristics those describing the originality of a creative course, for example, innovative M=3.25(1.21) and imaginative M=3.02(1.05). This result suggests that participants took into consideration the context of schooling and appreciated not only the originality but also the effectiveness of a course as an important quality of a creative course.

Two regression models were conducted to determine the predictors of the average originality and effectiveness of a solution since the correlation between the two outcome variables of average originality and potential effectiveness was non-significant (r=.07, p=.5). Due to the violation of the assumption of the residuals, instead of a multiple regression, an ordinal regression model was conducted to determine the predictors of average solution originality. Thus, the dependent variable was transformed into an ordinal variable with three levels of average originality (i.e., low, moderate, high) to determine the cumulative odds ratio of proposing a solution of high originality. High average originality ($\geq$.94) was manifested by 52 participants, moderate average originality (.86$\leq$ y $\leq$.93) was exhibited by 30 participants, and 21 participants scored low ($\leq$.85) in average originality.

Table 5

Predictors of Solution Originality

	Variable	Estimate	Wald	p	Confidence Intervals
Threshold	Low	-.828	0.47	.49	[-3.19, 1.53]
	Moderate	.572	0.23	.63	[-1.78, 2.93]
Parameter	Divergent Thinking (II)	0.20*	4.82	.03	[.02, 0.38]
	Beliefs	0.01	.03	.47	[-0.05, 0.02]

Academic Major	0.50	0.02	.90	[-0.73, 0.83]
Need for Cognition	-0.01	0.51	.86	[-0.05, 0.02]

The initial full ordinal regression model was non-significant. The non-significant predictors were removed stepwise and the ordinal regression model reached significance (-2LL=67.66, χ2(4) =5.08, p=0.02) with divergent thinking (Task II) being the only significant predictor (Table 5). Divergent thinking positively predicted average solution originality and for each unit increase in divergent thinking participants had lower cumulative odds of developing a solution of poorer originality (low or moderate) by a factor of 0.82.

A multiple linear regression with the same individual difference variables as predictors was performed (see Table 6) to determine their effect on the average effectiveness of creative solutions. The full model was significant but explained a modest amount of variation [F(4,97)=3.51, p=0.01, R2=0.13]. Academic major and need for cognition positively predicted the average effectiveness of a creative solution. For education majors, a solution was on average 0.24 (p=.02) more effective in comparison to a solution proposed by a non-education major. In addition, for each unit of increase in need for cognition there was a 0.21 (p=.03) increase in solution effectiveness.

Table 6

Predictors of Solution Effectiveness

Variable	B	β	p	Confidence Intervals
Constant	2.72**		<.001	2.18-3.27
Divergent Thinking (II)	0.03	0.12	.22	-0.02-0.07
Beliefs	-0.01	-0.1	.32	-0.02-0.01
Academic Major	0.23	0.24	.02*	0.04-0.43
Need for Cognition	0.01	0.21	.03*	0.001-0.02

3.3 Creative Solution Self-Evaluation

In the second research question we explored the effect of two alternative reflective tasks: the explanation and the argumentation task on the self-evaluations of the creative solution, with respect to its originality and effectiveness. A multivariate multiple regression (MMR) was performed with four predictors as covariates and the type of reflective task (1=Explanation, 2=Argumentation) as the fixed factor in the model. The covariates included beliefs about creative outcomes, academic major, and the average assigned originality and effectiveness score. The MMR analysis was conducted since the two outcome variables namely the effectiveness and originality self-evaluations were significantly and positively correlated (r12=.38, p<.001).

Table 7

Predictors of Creative Solutions Self-Evaluations

	Hotelling's Trace	*F*	*p*	Partial η^2	Observed Power
Intercept	.20	11.67	.001	.20	.99

Beliefs	.27	17.31	.001*	.27	1.00
Average Originality	.03	1.34	.27	.03	.28
Average Effectiveness	.001	.001	.99	.001	.05
Academic Major	.02	.77	.47	.02	.18
Condition	.11	5.77	.004*	.11	.86

The MMR model was significant [$F(2,94) = 11.67$, $p = < .001$, $\eta 2 = .20$]. The type of reflective task [$F(2,93) = 5.77$, $p = .004$, $\eta 2 = .11$] and beliefs about creative outcomes [$F(2,93) = 17.31$, $p = < .001$, $\eta^2 = .27$] had a significant effect on the self-evaluations (see Table 7). Specifically, the type of reflective task significantly and positively predicted the effectiveness self-evaluations [$F(1,94) = 11.23$, $p < .001$, $\eta^2 = .11$]. Participants in the argumentation condition evaluated their creative course by 2.81 [p=.001, 95% (1.14, 4.47)] points lower than participants in the explanation condition when all other predictors were equal. Thus, the argument diagram was a structure support that seems to have promoted more conservative self-evaluations about the proposed creative solution.

Participants' beliefs about the characteristics of creative outcomes were a significant positive predictor of the self-evaluations of originality [$F(1,94) = 14.63$, $p < .001$, $\eta^2 = .14$] and effectiveness [$F(1,94) = 28.74$, $p < .001$, $\eta^2 = .23$] of a forwarded creative solution. In fact, participants whose beliefs better aligned with the current conceptualizations of creative outcomes evaluated higher the creativity of their solution both in terms of its originality and effectiveness.

4. Discussion

Students across education levels are challenged to acquire complex cognitive skills including creative thinking. In this study we examined the individual difference variables that contribute to creative performance in problem solving with respect to the originality and effectiveness of a proposed creative solution. In addition, we attempted to address a gap in the literature related to the effect of argumentation tasks on the self-evaluation of creative solutions.

The major contribution of the present study is the development of the creative solution self-evaluation questionnaire which is a reliable rating scale that can be administered by teachers and used by students to evaluate creative solutions, ideas, and products with respect to a set originality and effectiveness criteria. However, the self-evaluation scale needs to be further validated to determine whether it yields the same underlying structure for creative outcomes across fields as it is also possible that additional criteria have to be met for an outcome to be judged as creative in a different field since influential individuals in each field evaluate ideas based on some consensus about the contribution of an idea in the field (Antiliou, 2010; Csikszentmihalyi, 1999).

Our investigation also contributes to the research efforts to identify the cognitive and affective variables that predict the creative performance of novices. The findings of the study aligned with research findings regarding the predictors of creative performance. Divergent thinking was reported as a predictor of creative problem solving (Diakidoy & Constantinou, 2001; Hunter et al., 2008; Reiter-Palmon et al., 1997), and this ability to generate various, distinct responses to a divergent thinking task was found in this study to be the single significant predictor of the originality of a proposed creative solution.

The effectiveness of a creative solution was predicted by affective and cognitive variables, specifically, need for cognition and academic major. The findings add to the existing evidence, which show that individuals with high need for cognition perform more effectively when solving complex problems (Butler et al., 2003; Nair & Ramnarayan, 2000; Osburn & Mumford, 2006). However, it is worrisome that participants reported moderate to low need for cognition since this cognitive disposition to enjoy effortful and challenging endeavours represents a prerequisite for lifelong learning and continued professional

development especially for future educators. Academic major served as a prior knowledge proxy and it positively predicted the effectiveness of the creative solution. In the future, researchers who aim to examine creative problem solving in specific disciplines could administer measures of domain knowledge such as the pedagogical/psychological (PPK) knowledge measure of general pedagogical knowledge (Voss, Kunter, Baumer, 2011) instead of relying on proxies of prior knowledge, which was a limitation in this study.

In the present study we also aimed to investigate the type of tasks that support more reflective self-evaluations of creative solutions. The findings of the study provide some indication that argumentation tasks facilitate more critical self-evaluations of the effectiveness of creative solutions. Participants who completed the argument diagram rated the effectiveness of their course more conservatively in comparison to those who responded to the explanation prompt, possibly because the argument diagram provided a structure support for students to elaborate, reflect more deeply and to critically analyze their proposed solution by considering alternative perspectives held by other stakeholders (Jonasssen & Kim, 2010; Nussbaum & Sinatra, 2003; Suthers, 2001). Further, Andriessen cited Baker (2004) to argue that argumentation is a mechanism through which students not only provide explanations but also prepare a justification to explicitly describe their rationale, which fosters better reflection. Munneke (2004) and colleagues also argued that as a knowledge representation tool a diagram explicitly presents the structure of argumentation, thus, providing an overview and making components and perspectives more visible. The fact that participants were more conservative about their solutions after completing the argumentation diagram provides some evidence for Voss's (1981) idea that argumentation is a mechanism that allows students to not only elaborate and clarify the solution but also identify potential limitations, thus, becoming more critical of their solution. However, more research evidence from a study based on a think aloud procedure is needed to provide stronger evidence on how students reflect on their solutions and whether the argument diagram itself promotes more reflective self-evaluations. Given that in the present study the design of the argument diagram guided students to apply the weighing argument-counterargument integration strategy, a follow-up study with a think aloud methodology would allow for a more authentic assessment of the integration strategies (e.g., synthesis, refutation, and minimization) that students choose to apply in tasks that require a creative solution that realizes benefits and minimizes disadvantages.

The findings of the study confirm the important role of beliefs as an affective variable that impacts problem solving with regard to the self-evaluations of a proposed creative solution rather than on creative performance per se. In fact, participants whose beliefs about the characteristics of creative outcomes aligned better with current conceptualizations in the literature rated both the originality and effectiveness of their solutions more positively. This finding signals the need for educators to pay more attention to affective dimensions of learning including students' beliefs since they inform critical thinking such as the self-evaluations of solutions. Teachers need to provide students with opportunities to explicate, contradict, and enrich their beliefs through classroom discussions, encounters with creative individuals, and exposure to examples of creative work across domains. When practitioners realize that students' beliefs are narrow or naïve they can also administer rating scales in advance to provide students with criteria for their self-evaluations. The finding also confirms that ontological beliefs about the nature of creative outcomes play an important role in the self-evaluation process. Educational researchers have shown interest in examining how epistemological beliefs impact problem solving performance (Lodewyk, 2007; Muis, 2008; Oh & Jonassen, 2007) but further research can be conducted in other knowledge domains by using approaches such as think aloud protocols, interviews, and classroom discourse to provide additional evidence on the role of ontological beliefs in creative problem solving in which learners have to draw on their creativity beliefs to define the problem and establish criteria to evaluate a potentially creative solution.

Thinking as argument is implicated in the beliefs that people hold, the judgments they make, and the conclusions they come to; it arises every time a significant decision must be made (Jonassen & Kim, 2010, p.439). Drawing on the findings of this study, we encourage educators who aim to facilitate students' critical thinking to use argument-based tasks in the form of diagrams to support students in generating, organizing, and evaluating their arguments and counterarguments in order to make more reflective evaluations during problem solving.

Keypoints

- Creative solutions were operationalized as original and effective and innovative procedures were used to measure these dimensions creative outcomes.
- The theoretical frame emerged from a literature review, which integrate two lines of research namely ill-structured and creative problem solving.
- The findings confirmed that argumentation diagrams can support reflective critical evaluations beyond writing tasks but in problem solving as well.
- A reliable self-evaluation scale was developed to assess characteristics of creative solutions which students and teachers can use to evaluate creativity

References

Anderson, L.W., & Krathwohl, D.R. (Eds.). (2001). A taxonomy of learning, teaching, and assessment: A revision of Bloom's taxonomy of educational objectives. New York: Longman.

Andriessen, J. (2006). Arguing to Learn. In: K. Sawyer (Ed.) *Handbook of the Learning Sciences* (pp.443-459). Cambridge: Cambridge University Press.

Andiliou, A. & Murphy, P. K. (2010). Examining variations among researchers' and teachers' conceptualizations of creativity: A review and synthesis of contemporary research, *Educational Research Review*, *4*(3), 201-219.

Antiliou, A. (2012). *The effect of an argumentation diagram on the self-evaluation of a creative solution*. (Unpublished doctoral dissertation). The Pennsylvania State University, University Park, PA.

Basadur, M., Runco, M. A., & Vega, L. A. (2000). Understanding how creative thinking skills, attitudes and behaviors work together: A causal process model. *Journal of Creative Behavior, 34*(2), 77-100.

Butler, A. B., Scherer, L. L., & Reiter-Palmon, R. (2003). Effects of solution elicitation aids and need for cognition on the generation of solutions to ill-structured problems. *Creativity Research Journal, 15*(2-3), 235-244. *Doi*:10.1207/S15326934CRJ152&3_13.

Byrne, C. L., Shipman, A. S., & Mumford, M. D. (2010). The effects of forecasting on creative problem-solving: An experimental study. *Creativity Research Journal*, *22*(2), 119-138.

Cacioppo, J. T., Petty, R. E., & Kao, C. F. (1984). The efficient assessment of need for cognition. *Journal of Personality Assessment*, *48*(3), 306-307.

Chen, C., & Bradshaw, A. C. (2007). The effect of web-based question prompts on scaffolding knowledge integration and ill-structured problem solving. *Journal of Research on Technology in Education, 39*(4), 359-375.

Chi, M.T.H. (2000). Self-explaining expository texts: The dual processes of generating inferences and repairing mental models. In R. Glaser (Ed.), *Advances in Instructional Psychology*, Hillsdale, NJ: Lawrence Erlbaum Associates.

Cho, K., & Jonassen, D. H. (2003). The effects of argumentation scaffolds on argumentation and problem solving. *Educational Technology Research and Development, 50*(3), 5-22.

Christensen, P. R., Merrifield, P. R., & Guilford, J. P. (1953). Consequences form A-1. Beverly Hills, CA: Sheridan Supply.

Csikszentmihalyi, M. (1999) Implications of a Systems Perspective for the Study of Creativity. In R. J. Sternberg, (Ed.), *Handbook of creativity* (pp. 313-335). New York: NY Cambridge University Press.

Dailey, L.R. & Mumford, M.D. (2006). Evaluative aspects of creative thought: Errors in appraising the implications of new ideas. Creativity Research Journal, *18*(3), 367-384.

Diakidoy, I. N., & Constantinou, C. P. (2001). Creativity in physics: Response fluency and task specificity. *Creativity Research Journal Special Issue: Commemorating Guilford's 1950 Presidential Address, 13*(3-4), 401-410.

Eggen, P. & Kauchak, D. (2010). Educational Psychology: Windows on Classrooms (8th ed.). New Jersey: Pearson Education.

Easterday, M.W., Aleven, V., & Scheines, R. (2007). Tis better to construct or to receive? Effect of diagrams on analysis of social policy. In R. Luckin, K. R. Koedinger, & J. Greer (Eds.), Proceedings of the 13th International Conference on Artificial Intelligence in Education (pp. 93-100). Amsterdam: IOS.

Felton, M., & Kuhn, D. (2001). The development of argumentative discourse skill. *Discourse Processes*, *32*(2&3), 135-153.

Ferretti, R. P., MacArthur, C. A., & Dowdy, N. S. (2000). The effects of an elaborated goal on the persuasive writing of students with learning disabilities and their normally achieving peers. *Journal of Educational Psychology*, *92*(4), 694-702.

Fonseca, B. A. & Chi, T. H. (2011). Instruction Based on Self-Explanation. In R. E. Mayer & P. Alexander (Eds.) *Handbook of research for learning and instruction*. New York, NY: Routledge

Ge, X., Chen, C., & Davis, K. A. (2005). Scaffolding novice instructional designers' problem-solving processes using question prompts in a web-based learning environment. *Journal of Educational Computing Research, 33*(2), 219-248.

Ge, X., & Land, S. M. (2003). Scaffolding students' problem-solving processes in an ill-structured task using question prompts and peer interactions. *Educational Technology Research and Development*, *51*(1), 21-38. *Doi*:10.1007/BF02504515.

Goldbrick-Lab, S., Carter F. D., & Wagner, R. W. (2007). What higher education has to say about the transition to college? *Teachers College Record, 109(10),* 2444-2481.

Hunter, S. T., Bedell-Avers, K. E., Hunsicker, C. M., Mumford, M. D., & Ligon, G. S. (2008). Applying multiple knowledge structures in creative thought: Effects on idea generation and problem-solving. *Creativity Research Journal, 20*(2), 137-154.

Isaksen, S. G. & Treffinger, D. J. (1985). *Creative Problem Solving: The Basic Course,* Buffalo, NY: Bearly Limited.

Jonassen, D. H. (1997). Instructional design models for well-structured and ill-structured problem-solving learning outcomes. *Educational Technology: Research & Development*, *45(1),* 65-94.

Jonassen, D.H., & Kim, B. (2010). Arguing to learn and learning to argue: Design justifications and guidelines. *Educational Technology: Research & Development*, *58,* 439-457.

Kim, S. (2001). *The effects of group monitoring on transfer of learning in small group discussions.* Unpublished doctoral dissertation, University of Illinois at Urbana-Champaign.

Kuhn, D. (1991). *The skills of argument*. Cambridge, UK: Cambridge University Press.

Leitão, S. (2003). Evaluating and selecting counterarguments. *Written Communication,* 20, 269-306.

Lodewyk, K. R. (2007). Relations among epistemological beliefs, academic achievement, and task performance in secondary school students. *Educational Psychology, 27*(3), 307-327.

Louie, V. (2007). Who makes the transition to college? Why we should care, what we know and what we need to do. *Teachers College Record*, *109*(10), 2222-2251.

Marttunen, M., & Laurinen, L. (2006). Collaborative learning through argument visualisation in secondary school. In S. N. Hogan (Ed.), *Trends in learning research.* (pp. 119-138). Hauppauge, NY, US: Nova Science Publishers.

Muis, K. R. (2008). Epistemic profiles and self-regulated learning: Examining relations in the context of mathematics problem solving. *Contemporary Educational Psychology*, *33*, 177-208.

Mumford, M.D., & Mobely, M. I., Uhlman, C. E., Reiter-Palmon, R., & Doares, L. M. (1991). Process analytic models of creative thought. *Creativity Research Journal*, *4*, 91-122.

Munneke, L. van Amelsvoort, M., & Andriessen, J., (2003). The role of diagrams in collaborative argumentation-based learning. *International Journal of Educational Research,* 39, 113-131.

Nair, K. U., & Ramnarayan, S. (2000). Individual differences in need for cognition and complex problem solving. *Journal of Research in Personality, 34*(3), 305-328.

Newell, G. E., Beach, R., Smith, J., & VanDerHeide, J. (2011). Teaching and learning argumentative reading and writing: A review of research. *Reading Research Quarterly, 46*(3), 273-304.

Nussbaum, E. M. (2008). Using argumentation vee diagrams (AVDs) for promoting argument-counterargument integration in reflective writing. Journal of Educational Psychology, *100*(3), 549-565.

Nussbaum, E. M., & Schraw, G. (2007). Promoting argument-counterargument integration in students' writing. *Journal of Experimental Education*, *76*, 59-92.

Nussbaum, E. M., & Kardash, C. M. (2005). The effects of goal instructions and text on the generation of counterarguments during writing. *Journal of Educational Psychology*, *97*, 157-169.

Nussbaum, E. M., & Sinatra, G. M. (2003). Argument and conceptual engagement. *Contemporary Educational Psychology*, *28*, 384-395. *Doi:*10.1016/S0361-476X(02)00038-3

Oh, S., & Jonassen, D. H. (2007). Scaffolding online argumentation during problem solving. *Journal of Computer Assisted Learning*, *23*(2), 95-110.

Osburn, H. K., & Mumford, M. D. (2006). Creativity and planning: Training interventions to develop creative problem-solving skills. *Creativity Research Journal*, *18*(2), 173-190.

Pritchard, M. E., Wilson, G., & Yamnitz, B. (2007). What predicts adjustment among college students? A longitudinal panel study. *Journal of American College Health*, *56*(1), 15-21.

Reiter-Palmon, R., Illies, M. Y., Cross, L. K., Buboltz, C., & Nimps, T. (2009). Creativity and domain specificity: The effect of task type on multiple indexes of creative problem-solving. *Psychology of Aesthetics, Creativity, and the Arts*, *3*(2), 73-80.

Reiter-Palmon, R., Mumford, M. D., O'Connor Boes, J., & Runco, M. A. (1997). Problem construction and creativity: The role of ability, cue consistency and active processing. *Creativity Research Journal, 10*(1), 9-23.

Reznitskaya A., Anderson, R. C., McNurlen, B., Nguyen-Jahiel, K., Archondidou, A., & Kim, S. Y. (2001). Influence of oral discussion on written argument. *Discourse Processes*, *32*(2&3), 155-175.

Roe Clark, M. (2005). Negotiation the Freshman Year: Challenges and Strategies Among First-Year College Students. *Journal of College Student Development*, *46*(3), 296.

Runco, M. A., & Chand, I. (1994). Problem finding, evaluative thinking, and creativity. In M. A. Runco (Ed.), *Problem finding, problem solving, and creativity*. (pp. 40-76). Westport, CT, US: Ablex Publishing.

Scwarz, B. B., Neuman, Y., & Biezuner, S. (2000). Two wrongs may make a right ...if they argue together! Cognition and Instruction, 18(4), 461-494.

Shin, N., Jonassen, D. H., & McGee, S. (2003). Predictors of well-structured and ill-structured problem solving in an astronomy simulation. *Journal of Research in Science Teaching*, *40*(1), 6-33.

Suthers, D. D. (2001). Towards a systematic study of representational guidance for collaborative learning discourse. *Journal of Universal Computer Science*, 7(3), 254–277.

Toulmin, S. E. (1958). *The uses of argument.* Cambridge, England: Cambridge University Press.

Uribe, D., Klein, J. D., & Sullivan, H. (2003). The effect of computer-mediated collaborative learning on solving ill-defined problems. *Educational Technology Research & Development, 51*(1), 5-19.

van Eemeren, F., & Grootendorst, R. (1999). Developments in Argumentation Theory. In J. Andriessen & P. Coirier (Eds.). *Foundations of argumentative text processing* (pp. 43-57). Amsterdam: Amsterdam University Press.

Van Eemeren, F. H., & Grootendorst, R. (1992). Argumentation, communication, and fallacies: A pragma-dialectical perspective. Hilisdale, NJ: Lawrence Erlbaum Associates.

Voss, J. F. & Post, T. A. (1988). On the solving of ill-structured problems. In M. T. H. Chi, R. Glaser & M. J. Farr (Eds.), *The nature of expertise* (pp. 261-285). Hillsdale, NJ: Lawerence Erlbaum Associates.

Voss, J. F., Wolfe, C. R., Lawrence, J. A., & Engle, R. A. (1991). From representation to decision: An analysis of problem solving in international relations. In R. J. Sternberg, & P. A. Frensch (Eds.), *Complex problem solving: Principles and mechanisms.* (pp. 119-158). Hillsdale, NJ, England: Lawrence Erlbaum Associates.

Voss, T., Kunter, M., & Baumert, J. (2011). Assessing teacher candidates' general pedagogical and psychological knowledge: Test construction and validation. *Journal of Educational Psychology, 103*(4), 952-969.

Walton, D. (2000). The place of dialogue theory in logic, computer science, and communication studies. Synthese, 123, 327-346.

Walton, D. N. (1996). Argumentation schemes for presumptive reasoning. Mahwah, NJ: Laurence Erlbaum Associates.

Weisberg, R. W. (2006). Expertise and reason in creative thinking: Evidence from case studies and the laboratory. In J. C. Kaufman & J. Baser (Eds.) *Creativity and Reason in Cognitive Development* (pp. 7-42). New York: Cambridge University Press.

Wiley, J., & Voss, J. F. (1999). Constructing arguments from multiple sources: Tasks that promote understanding and not just memory for text. *Journal of Educational Psychology*, *91*(2), 301-311.

APPENDIX

Effectiveness Scoring Rubric

Table 8

Effectiveness Scoring Rubric for the Coded Task-Relevant Units

Score	Descriptor
4-Strong	The learning activity or other instruction/course design element ▪ **targets important** information, knowledge, abilities, skills and strategies for **academic success** in college or **smooth transition** to college. ▪ **strongly aligns** with the overall goal of the course.
3-Moderate (weak/strong) **OR** (strong/weak)	The learning activity or other instruction/course design element ▪ **targets somewhat important** information, knowledge, abilities, skills and strategies for **academic success** in college or **smooth transition** to college. ▪ **strongly aligns** with the overall goal of the course. The learning activity or other instruction/course design element ▪ **targets important** information, knowledge, abilities, skills and strategies for **academic success** in college or **smooth transition** to college. ▪ **weakly aligns** with the overall goal of the course.
2-Weak (weak/weak)	The learning activity or other instruction/course design element ▪ **targets somewhat important** information, knowledge, abilities, skills and strategies for **academic success** in college or **smooth transition** to college. ▪ **weakly aligns** with the overall goal of the course.
1-Insufficient (weak/inadequate) **OR** (inadequate/weak)	The learning activity or other instruction/course design element ▪ **targets somewhat important** information, knowledge, abilities, skills and strategies for **academic success** in college or **smooth transition** to college. ▪ **does not align** with the overall goal of the course. The learning activity or other instruction/course design element ▪ **does not target** information, knowledge, abilities, skills and strategies for **academic success** in college or **smooth transition** to college. ▪ **weakly aligns** with the overall goal of the course.
0-Inadequate (inadequate/inadequate)	The learning activity or other instruction/course design element ▪ **does not target** information, knowledge, abilities, skills and strategies for **academic success** in college or **smooth transition** to college. ▪ **does not align** with the overall goal of the course.